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~~P01/7700 0.00-0317508.0~~

1.	**Your reference**	74.66.81304
2.	**Patent application number** *(The Patent Office will fill in this part)*	0317508.0 — 25 JUL 2003
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	4Cyte Limited The Tyrrell Building Long Reach Ockham Surrey GU23 6PG United Kingdom
	Patents ADP number *(if you know it)*	8151615001
	If the applicant is a corporate body, give country/state of incorporation	United Kingdom
4.	**Title of the invention**	A Method and Apparatus for Forming a Coated Moulding
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001
6.	**If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and** *(if you know it)* **the or each application number**	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	**If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application**	Number of earlier application / Date of filing *(day / month / year)*
8.	**Is a statement of inventorship and of right to grant of a patent required in support of this request?** *(Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))*	Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document	
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Claim(s)	0
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Translations of priority documents	0
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Request for preliminary examination and search *(Patents Form 9/77)*	0
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Any other documents *(please specify)*	No
11.	**I/We request the grant of a patent on the basis of this application.** **Signature** [signature] **Date** 25 July 2003
12. Name and daytime telephone number of person to contact in the United Kingdom	David Leckey 01273 244200

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A METHOD AND APPARATUS FOR FORMING A COATED MOULDING

The invention relates to a method and apparatus of forming a coated moulding, more particularly a coated moulding formed by dual injection.

Dual injection moulding is a technique in which a first material is injected into a mould followed by a second material. The first material coats the mould surfaces, while the second material forms a substrate for the first. The moulded component may harden in the mould prior to removal from the mould.

Such a dual injection process may be used to provide a paint coating on a moulded plastics body. In such a process paint is injected as the first material and the base plastic as the second material. Such a process has the advantage that the moulding is co-formed with a paint coating and thus does not need subsequent painting.

An example of a dual injection moulding process which produces a pre-painted moulding is disclosed in GB 2280401. This document discloses a method of forming a painted moulding wherein a powdered or granulated plastics paint material is heated and injected into a mould, followed by the injection of a substrate plastic. The use of powdered or granulated plastics enables a more controllable flow to be obtained in the mould resulting in a paint coating thickness which is more uniform.

However, a significant disadvantage of using this technique is that the flow of the paint coating material within the mould, and hence the moulding's finished appearance, is highly dependent upon the shape of the mould. Moulds having simple, continuous surfaces generally produce mouldings with a coating of a reasonably consistent thickness and appearance. However, moulds having irregularly shaped or discontinuous surfaces distort the flow of the paint coating material within the mould and hence result in the product having a coating of non-uniform thickness or having a distorted appearance.

For example, a mould formed to produce a moulding having holes or protrusions causes non-uniform flow lines about these regions, resulting in the moulding having a distorted appearance. This is particularly visible when a metallic paint finish is required, because the reflective, metallic flakes used in the coating material align with the flow lines of the coating.

Furthermore, because the paint coating is injected into the mould it is not possible to produce an image on the moulding surface or vary the appearance over the surface.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for forming a pre-coated moulding by a dual injection process, wherein the moulding has an appearance which is not distorted by the flow lines of the coating material.

A further object of the present invention is to provide a method and apparatus for forming a pre-coated

moulding having a predetermined image, pattern or texture thereon.

From a first aspect there is provided a method of forming a moulding by injection moulding comprising; injecting a coating material into a mould, the coating material including magnetic particles; injecting a substrate material into the mould behind the coating so that the coating material covers a surface of the mould; and applying a magnetic field to at least a portion of the coated material so as to change the orientation and/or distribution of magnetic particles in the coating material.

From a second aspect there is provided a moulding apparatus comprising; a mould; means for injecting a coating material including magnetic particles into the mould; means for injecting a substrate material into the mould; and means for applying a magnetic field in the mould so as to change the orientation and/or distribution of magnetic particles within the coating material.

Thus in accordance with the invention, a coating material is used which contains magnetic particles, and a magnetic field is applied to the coating material in the mould so as to cause a desired orientation and/or distribution of the particles in the coating to give a desired visual effect. By choice of an appropriate magnetic field it is possible to compensate for the irregular surface appearance caused by non-uniform flow lines within the mould. Furthermore, the magnetic field may also be such as to form a desired image in the coating.

More particularly, the concentration and/or orientation of the magnetic particles within a given region of the coating will determine the appearance of the moulding surface. These properties may be manipulated and controlled by the magnetic field to produce any desired surface appearance. The magnetic particles align along the magnetic fields which are applied to the coating. Thus, in a preferred embodiment, for example, the level of light reflection/absorption by the magnetic particles may be altered by changing the particles orientation and/or concentration. For example, the magnetic fields may be arranged to move the magnetic particles into or from a particular region or change the orientation of the magnetic particles such that light is incident on a larger area of the particles to increase the reflectivity or absorption of the region.

In moulds having irregular or discontinuous surfaces such as holes or protrusions the present invention can also be employed to compensate for the distorted appearance created at these regions. The magnetic fields may be arranged such that the magnetic particles are drawn to give a uniform coating and/or be orientated in the required direction. Any desired image may also be formed on the moulding surface by arranging the magnetic fields to draw or push reflective or absorptive magnetic particles to or from regions of the coating. In this manner a two-dimensional, three-dimensional or textured appearance may be created on the coating during the moulding process.

The magnetic particles which are included in the coating material may consist of a magnetic core which

may be spherical, elongated or any other shape. Preferably, the magnetic core is elongated and coated with an outer layer consisting of a material which reflects or absorbs light relatively well.

In a preferred embodiment the magnetic particles are nickel. In some embodiments the particles may comprise a nickel core which may be coated in, for example, aluminium, or alternatively coated with, for example, magnesium fluoride and aluminium or another metal. The magnetic particles may also have coloured coatings.

In a preferred embodiment the magnetic particles comprise leafing grade nickel flakes such as those manufactured by Novamet Speciality Products Corporation. Such flakes may be used in a coated or uncoated state. More preferably, extra fine pigment grade nickel flakes are used in the coating. The magnetic particles can be added to the coating material as a dry powder or pigment slurry. The magnetic particles preferably make up 2-15% of the coating material by weight. More preferably, the magnetic particles comprise 3-10% of the coating material by weight. Even more preferably, the magnetic particles make up 5% of the coating weight.

The magnetic fields which manipulate the magnetic particles may be generated by one or more permanent magnet or electromagnets provided in the region of the mould.

The poles of the magnets may be arranged such that the magnetic fields are substantially parallel, perpendicular or oblique to the surface of the paint coating.

These magnets may be recessed into or formed integrally with the inner or outer surfaces of the mould, or disposed between the inner and outer surfaces. Alternatively, the magnets may be arranged adjacent to the surfaces of the mould.

In some embodiments an electromagnet is used, particularly when it is desired that the magnetic field is applied only selectively during the moulding process.

Any number of magnets having any shape or size may be used in the apparatus depending upon the desired pattern or effect to be achieved. The strength of the magnetic field and the duration that it is applied may also be varied depending upon the effect to be achieved, the distance and material between the magnet and coating and the level of curing of the coating.

In order to vary the strength or position of the magnetic fields the magnetic field generating means may be movable relative to the mould. In such an embodiment magnets may be positioned, for example, within bores in the mould casing and may move perpendicularly or parallel to the coating. Alternatively, if electromagnets are employed, the power delivered to them may be varied.

In the present invention liquid, powdered or granulated paint material may be used as the coating material. The paint material is preferably heated to a plastic condition and injected into the mould. It is particularly preferred to use a powdered or granulated plastics paint of a thermosetting kind which has a thermoplastic phase, with the magnetic pigment mixed therewith. In such a case the powdered or granulated plastics paint can be heated sufficiently to bring it to

a plastic condition (typically a putty-like conditions) in its thermoplastic phase to enable it to be injected at high pressure into the mould (e.g. in excess of 1000 bar). For example heating a powdered or granulated plastics paint to a temperature in the range 80° to 260°C will normally bring it to a plastic condition for injection into the mould. With such a coating material, the heat absorbed to bring it to the plastic phase may ideally be utilised to cause the material to begin thermosetting, e.g., as it coats the mould or after it has coated the mould following the introduction of the substrate material. In that way a reasonably rapid curing of the coating can be achieved once it has coated the mould. However, if desired, the coating can be cured or curing can be completed after removal of the moulding from the mould, i.e. post-cured.

Post curing enables the curing temperature and time to be particularly carefully controlled preferably with a view to creating a strong bond between the two materials.

The paint and substrate materials are preferably selected so as to have an affinity one for the other. Cross-linking between the moulded coating and substrate material may be effected during moulding or curing of the material.

The method and apparatus provided in accordance with the present invention are particularly suited to the production of casings for electronic equipment and various body components of a motor vehicle.

Various embodiments of the present invention will now be described, by way of example only, and with reference to the following drawings in which:

Fig. 1 is a diagrammatic cross section through a dual injection moulding machine showing the injection into a mould of coating material comprising magnetic particles.

Fig. 2 is a diagrammatic cross section through a dual injection moulding machine showing the injection into a mould of substrate material.

Fig. 3 is a diagrammatic cross section through a dual injection moulding machine showing the form of the moulding after injection of the substrate material.

Fig. 4 is a diagrammatic cross section through a dual injection moulding machine showing another injection of the coating material to coat the substrate at the region of the injection port.

Fig. 5 is a diagrammatic view of the moulding removed from the mould and placed in an oven for post curing the coating.

Fig. 6 is a cross section to a larger scale through part of a component made by a method in accordance with the present invention.

Fig. 7 is a partial view of a cross section through a dual injection moulding machine showing the alignment of the magnetic particles in the coating material.

With reference to Fig. 1, a dual injection moulding machine has a mould 10 having first and second halves 12, 13 defining a hollow cavity 14 therebetween. The hollow cavity 14 communicates with a block 15 which defines a passageway 16 for material from a first extruder 17 and a second passageway 18 for material from a second extruder 19. A rotary valve 20 is positioned between the block 15 and an inlet port 22 in mould half 13 for selection of the material to be injected into the

cavity 14. A number of permanent magnets 21 are arranged within the mould halves 12,13 in a desired position.

The first extruder 17 is associated with a heater 17a and is operated to deliver a coating material 23 comprising magnetic particles. The coating material may consist of liquid paint or may be formed by heating thermosetting granulated plastics paint material 23a including the magnetic particles into a thermoplastic phase in which it takes on a putty-like plastic condition. A suitable granulated plastics paint material has been found to be one which will have a plastic condition at a temperature of around 170° with a putty-like viscosity.

An initial quantity of the coating material 23 is injected into the cavity 14, the mould being at a temperature in a range of, for example, 20°C to 100°. The valve 20 is then rotated to shut off feed of coating material 23.

Fig. 2 shows the step in which the substrate material is injected. A thermoplastics substrate material 24, such as ABS or nylon 24a, is heated in a heater 19a associated with the second extruder 19 and is injected into the cavity behind the injected coating material 23a. Injection of the substrate material 24 causes the coating material 23 to spread over the mould surfaces 14a defining cavity 14 and injection is continued until the mould's inner surfaces are coated with the coating substrate material 23, which also envelopes the substrate material 24.

Fig. 3 shows a cross-section of the machine after injection of the coating material 23 and substrate material 24. It can be seen that the material 24 forms a thermoplastics substrate or core having a coating or skin formed by the coating material 23.

The magnets 21 produce a magnetic field within the mould 10. The magnets 21 are arranged such that the fields manipulate the magnetic particles in the fluid coating material 23 before it has cured. The magnetic fields may be arranged to distribute and/or re-orientate the magnetic particles such that the moulding has a paint coating with a uniform appearance, or alternatively, to produce a coating on which at least a portion is created having a 2-D, 3-D or textured appearance.

In Fig. 4, the valve 20 is rotated again to shut off feed from the extruder 19 and to again permit injection of coating material into the port 22 so that the machine is ready for another injection cycle. The coating material 23 is injected into the mould 10 to coat the substrate in the region of the entrance port 23.

The heat applied to the thermosetting coating material 23 while it is temporarily in the extruder 17 is absorbed by the material and, once in the mould 10, the heat will begin the curing process of the material. That process may begin as the material is being spread over the mould surfaces by the incoming substrate material or may begin after the injection steps are complete. However, the magnetic fields are applied to manipulate the print coating before the curing process is completed.

Preferably, the curing of the thermosetting coating material 23 and substrate material 24 will also allow sufficient time to enable cross-linking to take place between the two materials thereby ensuring an extremely good bond between them. Instead of a cross-linking occurring between the coating and substrate materials, a good bond alone may be achieved between them due to their intimate contact during injection.

Referring to Fig. 5, the moulding 11 can be removed from the mould 10 and placed in an oven 30 to further heat and cure the coating material 23. The oven is pre-heated to a temperature of around, for example 250°C. The moulding 11 is subjected to heat at that temperature as indicated by arrows for a period which is sufficient to cure the coating material 23 but which is insufficient to have a significant softening effect on the bulk of the thermoplastics substrate material 24. Further magnetic fields may be applied to the moulding at this stage if desired. It is believed that with careful control of timing and temperature, a good bond will be achieved between the coating material 23 and the substrate material 24.

The substrate material 24 is preferably selected so that it will have an affinity to the coating material 23 and materials such as ABS and nylon constitute suitable substrate materials for such a coating material 23.

Referring to Fig. 6, the depth d of the coating material 23 can be selected to be at least as thick as a paint coating which would normally be applied to, say, a car body component in a paint spraying or dipping facility. Also, the injection moulding tool 10 can provide a superfine surface finish for the coating which

will compare well with that obtained by spray or dip painting.

Moreover, by producing a coating in a dual injection moulding process, the finished coating will be free from contamination by air-borne dust as well as being uniform and consistent. Also, the method is cleaner and more environmentally friendly than producing a finish using a conventional paint facility as the process does not involve extracting contaminated air or effluent from a paint facility into the atmosphere.

If desired, the substrate material 24 can be a thermosetting material instead of a thermoplastics material. The injection steps will be the same as that described above with reference to the drawings except that the mould will be hotter, for example, at a temperature in a range 100°C to 180°C. As before, the heat applied to the coating material 23 will lead to the onset of curing and the hot mould will speed up curing of the coating formed by coating material 23. The heat from the mould may also at least partially cure the substrate material 24. If desired the moulding can be left to cure completely in the mould 10 or can be removed for post curing outside the mould, for example, in the oven 30. In the latter case heat applied to the thermosetting substrate material 24 will not present any distortion problems to the thermosetting material.

The substrate material 24 may be injected as a foamed thermoplastic/thermosetting material.

Fig. 7 shows a portion of a cross section through the dual injection moulding machine. In this embodiment elongated magnetic flakes 40 have been added to the coating material 23. It has been found that as the

coating material 23 spreads over the surfaces 14a of mould cavity 14, the spreading or flowing action causes the magnetic flakes 40 to orientate themselves so that they lie generally in a plane parallel with the flow. It can be seen that in this embodiment the magnetic fields have been arranged to orientate the magnetic flakes 40 in substantially the same direction and concentration throughout the coating layer 23 such that a moulding having a uniform appearance will be produced, regardless of the direction of the flow lines. In addition the magnetic fields may orientate the flakes 40 to lie within the confines defined by the surfaces 14a of cavity 14 so as not to project from the finished paint surfaces of the moulding.

Although the present invention has been described with reference to the preferred embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention as set forth in the accompanying claims.

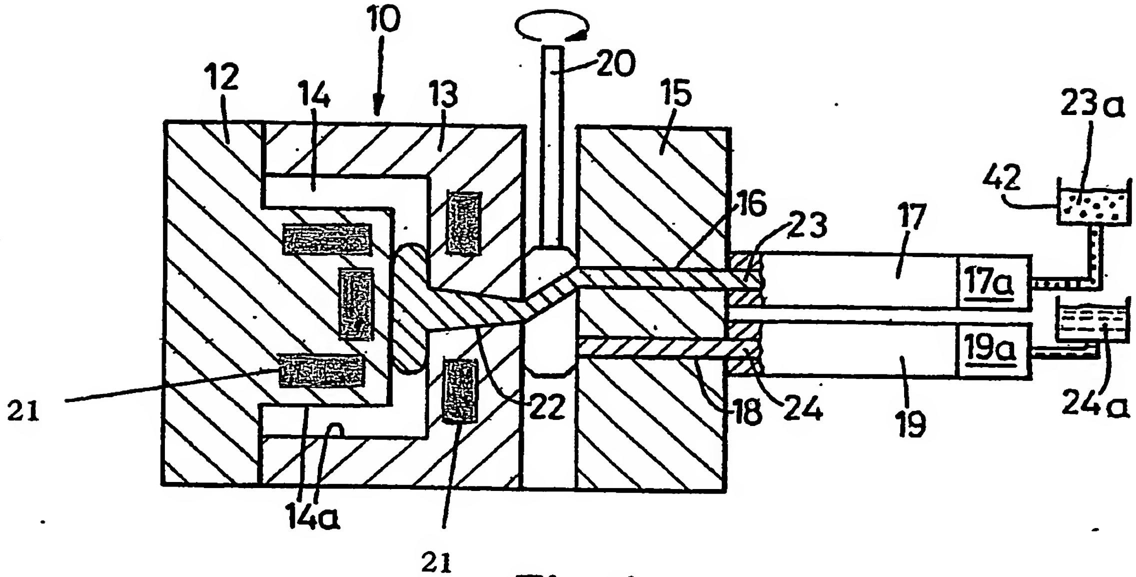
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Fig. 1

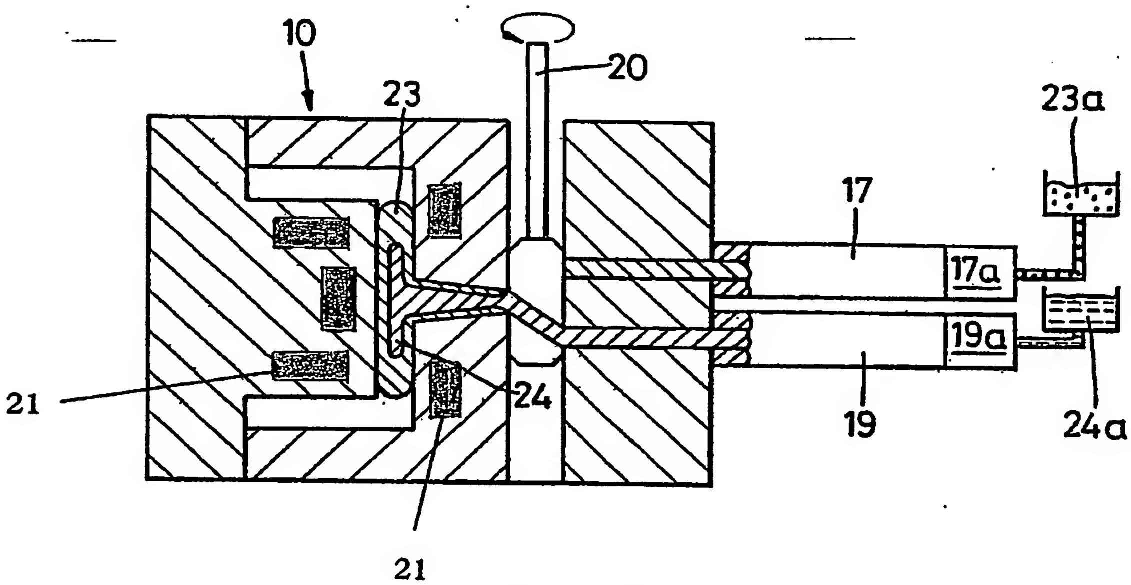
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Fig. 2

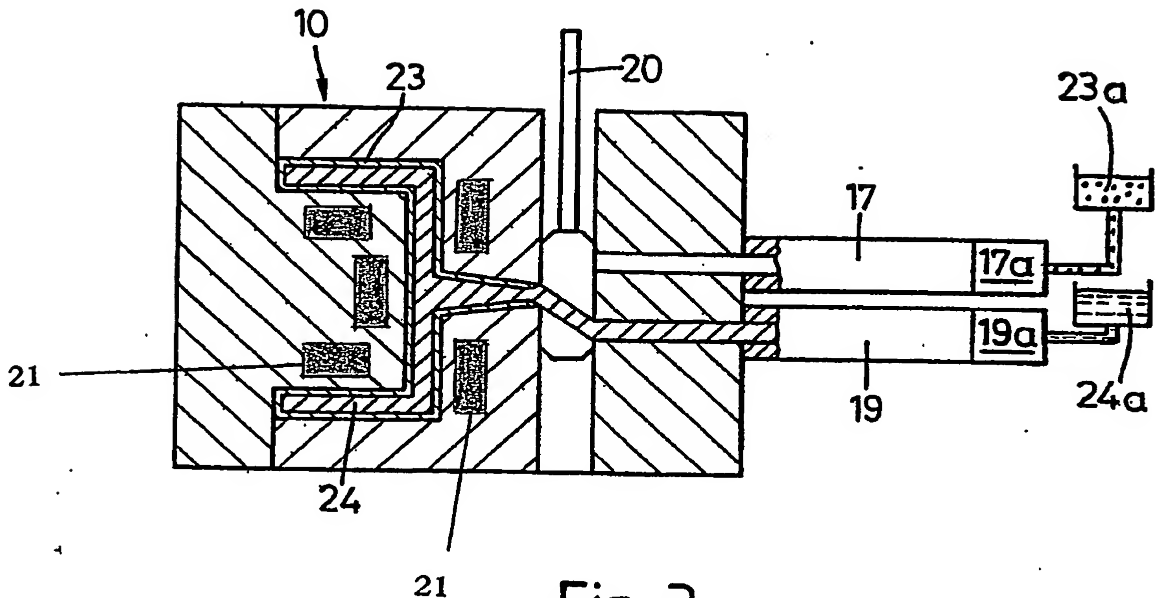
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Fig. 3

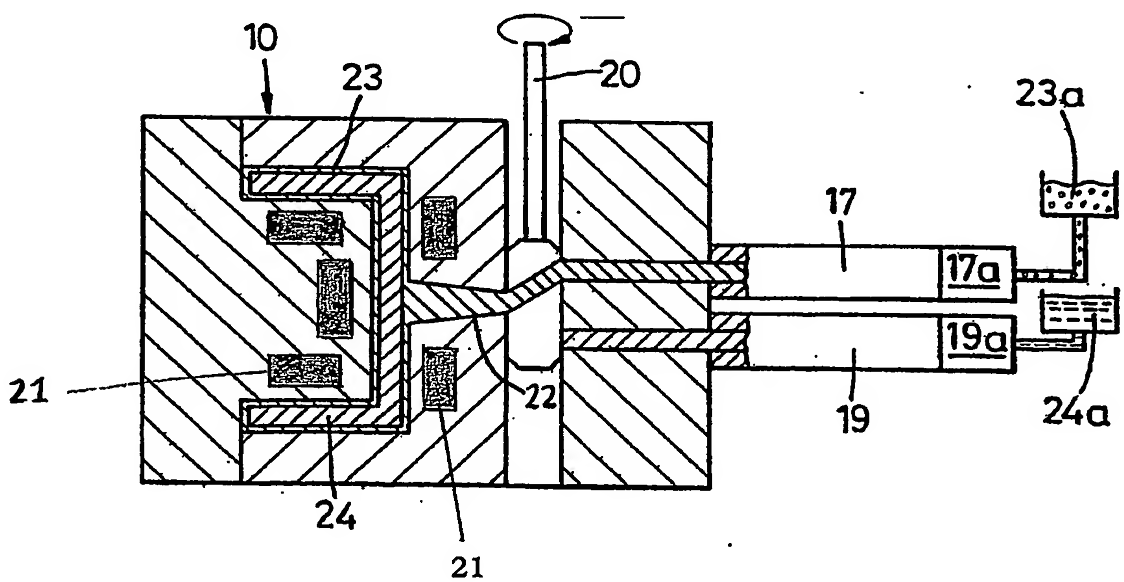
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Fig. 4

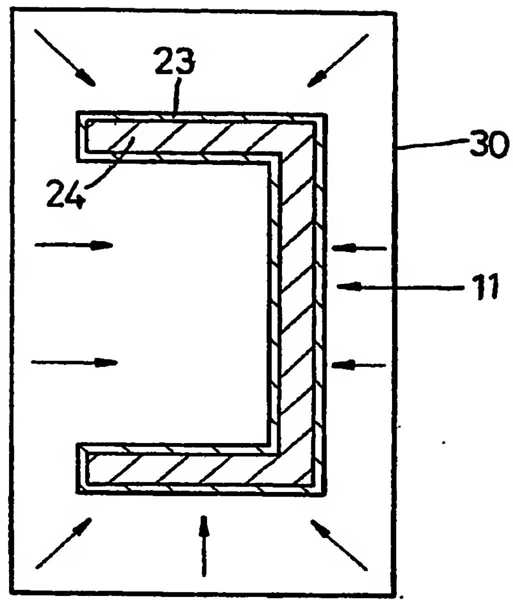

Fig. 5

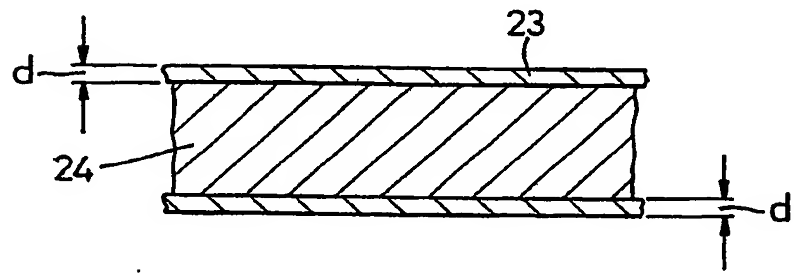

Fig. 6

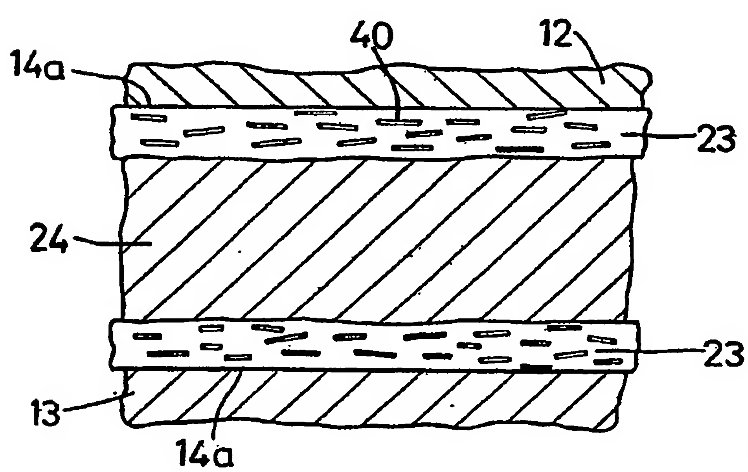

Fig. 7